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November 30, 1988

Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N. W.
Washington, D. C. 20554

Re: MM Docket No. 87-268

Dear Ms. Searcy:

Transmitted herewith, on behalf of Tele-Communications, Inc., are an original and five (5) copies of its Comments in the above-referenced matter.

Should any questions arise, please communicate with the undersigned.

Sincerely,

James E. Meyers

James E. Meyers
Counsel for
TELE-COMMUNICATIONS, INC.

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Attachment

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:	)	
	)	MM DOCKET NO. 87-268
Advanced Television Systems and Their Impact on the Existing Television Broadcast Service	)	
	)	
Review of Technical and Operational Requirements: Part 73-E, Television Broadcast Stations	)	
	)	
Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules	)	

COMMENTS
OF
TELE-COMMUNICATIONS, INC.
TO TENTATIVE DECISION AND FURTHER NOTICE OF INQUIRY

Tele-Communications, Inc. ("TCI"), through undersigned counsel, submits its comments to the Tentative Decision and Further Notice of Inquiry, FCC 88-288, released September 1, 1988 ("Tentative Decision"). TCI is a cable television multiple system operator.

I. INTRODUCTION

No other set of policy decisions confronting the Commission in the rest of this century will have as profound an impact on the quality of television pictures Americans will see as that of the transition to Advanced Television Systems ("ATV"). With a television set in virtually every American household, the Commission's allocation of ATV frequency for terrestrial television broadcast service also profoundly affects the public

interest, overshadowing frequency allocation considerations for any of the non-mass media services, except perhaps the emergency services. Moreover, the decisions apparently could have an enormous impact on our international trading posture as well.[1]

TCI believes the Commission's Tentative Decision implies insufficient consideration of the symbiotic relationship between cable television and television broadcasters. Cable began as a means of delivering broadcast signals to households that could not otherwise receive them off-air, and, even today, when there are numerous cable channels and program services available, one of the primary reasons subscribers purchase cable service is to get a more satisfactory local broadcast signal. Cable subscribers spend about sixty-seven percent (67%) of their cable viewing time watching over-the-air terrestrial broadcast stations. The relationship is particularly important for UHF

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[1] Within a week of the Commission's release of its Tentative Decision at hearings on HDTV, the House Telecommunications and Finance Subcommittee called for industry consensus and proposed HDTV policy options by January 4, 1989, amidst deep concern with de facto preemption of any major American role in the world HDTV market. Communications Daily (September 8, 1988) at 1-2. The Department of Commerce, likewise concerned with domestic share of a manufacturing market that could account for a $20 billion business in the U.S. in ten years, announced the assembly of a 14-member panel of communications industry representatives to study the effects of HDTV implementation on domestic manufacturers. Multichannel News (November 21, 1988) at 1, 65. Concern with the U.S. future in HDTV was alarmingly repeated in the Electronics Association of America's recent warning that if American industry fails to become a leading player in the emerging market for HDTV, the United States could lose its lead and substantial market share in personal computers, automated manufacturing equipment and semi-conductors. The New York Times (November 23, 1988) at D-1.

stations whose viewing area and signal quality are enhanced considerably by cable carriage.

TCI favors the continuation and strengthening of the symbiotic relationship between the cable and broadcast industries as television moves into a new technological era featuring higher definition picture quality. However, for this relationship to persist, the transition to ATV requires a far-sighted allocation policy that fosters optimum terrestrial broadcast HDTV in a bandwidth that is reasonable for both broadcast and cable. In the foreseeable future, bandwidth will not be unlimited for either broadcast or cable, and even with technological advancements in digital and fiber transmission systems, there will always be economic limits on the amount of bandwidth any cable service provider can reasonably ask subscribers to finance with subscription fees.

TCI does not favor ATV development which excludes the broadcast community.[2] By the same token, it does not intend to be excluded itself by standards which force upon the cable industry interim bandwidth requirements that are not realistic given the state of the technology, current consumer demand and other economic factors.

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[2] House Telecommunications and Finance Subcommittee Chairman Markey, critical of the Commission's Tentative Decision, warned that absent an active role by the Commission, HDTV would propel "right past broadcasters to the consumer public through the media of cable and DBS." Communications Daily (September 8, 1988) at 3, quoting Rep. Markey's remarks to MST's September 7, 1988, seminar on ATV.

The Commission, particularly over the near term, should not be considering options that require radically new television sets, transmission methods or program production standards. Above all, the Commission must itself engage in active and vigilant oversight of ATV development, which must include the difficult task of reserving adequate bandwidth for use when ATV advancements are proven to be technologically feasible and accepted by the consumer.

II. A 6 MHz NTSC COMPATIBLE ATV IS THE OPTIMUM TRANSMISSION STANDARD UNTIL NEXT GENERATION HDTV

As part of TCI's ongoing evaluation of ATV, it engaged the consulting telecommunications engineering firm of Moffet, Larson & Johnson, Inc., to prepare a report on ATV in light of the Commission's Tentative Decision ("Johnson Report"). The Johnson Report, attached hereto as Attachment 1, recommends an ATV approach that substantially reflects the Commission's basic spectrum Option Number One: No additional spectrum allotment. See Tentative Decision at 38-39.[3] The Johnson Report concludes

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[3] The Commission believes and TCI agrees that a rapid transition would occur to a 6 mHz NTSC compatible ATV transmission standard. The Commission recognized that a 6 mHz compatible ATV system will have only a relatively small economic impact on broadcasters, cable operators, and consumers. Broadcasters would not need to replace or add transmitters nor would cable operators be required to expand channel capacity or discontinue existing service. Consumers' existing receivers would be unaffected yet their new ATV receivers would be able to receive enhanced television. Moreover, LPTV and translators would not be displaced. The Commission also recognized the advantages of a fully compatible system in both high consumer demand and speedy achievement by manufacturers of economies of (continued...)

that the substantial benefits associated with a 6 MHz NTSC compatible ATV transmission standard far outweigh the transition to an analogue HDTV standard and the range of frequency allotment options considered by the Commission as part of that process. Johnson Report at passim.[4]

Since proposed enhancements to the present 6 MHz NTSC system will provide features and quality that rival the more bandwidth-intensive HDTV approaches under consideration, consumer satisfaction data are acutely necessary before the Commission moves away from an enhanced television standard.[5] The absence at this juncture of these data add an unacceptable element of risk to favoring an HDTV approach to advanced television now. Moreover, preliminary indications are that consumer satisfaction with enhancement of the 6 MHz NTSC system will be high. Johnson

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[3](...continued)
scale in production that would lead to lower prices for consumers. Tentative Decision at 38-39.

As discussed in the above following text, TCI does not urge future assignment of additional full service television stations or land mobile spectrum because of potential transitional spectrum demands of next generation HDTV technology.

[4] The Johnson Report identifies (with the possible exception of the Zenith proposal) substantial interference potential to existing UHF service from the proposed HDTV systems utilizing 3 MHz and 6 MHz augmentation frequency. Johnson Report at 3-6.

[5] The Johnson Report explains that realistic display sizes available over the next few years in a typical consumer environment will limit the public's ability to discern true HDTV from enhanced TV service. Johnson Report at 8.

Report at 14. TCI's early development and testing of the American enterprise of Faroudja Laboratories, Inc., "Super NTSC" system promises to validate in the home environment an enhanced picture virtually indistinguishable from an HDTV picture.[6]

HDTV penetration to consumer homes will be slow, further discouraging implementation now with the attendant costs NTSC incompatibility will impose. Moreover, the entrenchment of NTSC in world markets, in the United States' market size and the high level of American television viewership make it extremely unlikely that a de facto HDTV standard will emerge during an interim enhanced television transition period, particularly if the Commission reaffirms NTSC.

It is not likely that an optimum system, sensitive to the demands of the American communications infrastructure and the high value placed on spectrum, will be developed if the HDTV approaches under consideration are adopted. Moreover, the HDTV proposals under consideration may hinder future advancements in HDTV and home video technology. Johnson Report at 5-6. The momentum created by implementing HDTV from among the current generation of system proposals will force HDTV development to

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6 TCI and certain elements of the broadcast industry are developing and testing "Super NTSC" with Faroudja Laboratories, Inc., for introduction in the near term. Now available in prototype, the system utilizes 6 MHz and is fully NTSC compatible, is capable of providing 35 mm image quality, employs 1050 lines and eliminates NTSC artifacts. Attached hereto as Attachment 2 is a description of the system by Faroudja Laboratories, Inc., as part of its demonstration at the House Telecommunications and Finance Subcommittee on September 8, 1988.

occur within constraints imposed by the analogue transmission process. The allocation of spectrum, the accompanying investment in new incompatible equipment, and the implementation of NTSC phase-out will have indelible effects on how terrestrial broadcasting will participate in the next generation of HDTV. The Commission observed significant costs associated with implementing HDTV from among the systems under consideration. Tentative Decision at 38-41. The loss of the substantial benefits to be gained from a NTSC compatible 6 MHz interim standard and the development of optimum next generation broadcast HDTV are immeasurable costs that the Commission should consider.

TCI agrees with the Johnson Report and with those parties that favor a more gradual and studied approach utilizing the interim ATV step of 6 MHz NTSC compatible enhanced television. During the interim, valuable time will have been gained and the present symbiotic relationship between cable operators and broadcasters maintained in order that an interoperable HDTV transmission standard can be developed that is sensitive to the communications needs of the United States and the premium placed on spectrum.

III. A DIGITAL HDTV TRANSMISSION STANDARD SHOULD BE FOSTERED

The next generation in HDTV necessarily must encompass a digitally-processed transmission standard. Various proponents of the HDTV systems under consideration advance their systems on the basis that Digital HDTV ("D-HDTV") transmission technology is not

yet available.[7] D-HDTV will evolve in tandem with worldwide trends towards digital processing. In the consumer electronics industry, the trend toward digital systems can be seen in some of the primary components of television, such as recording techniques, control systems, image processing, and displays. Johnson Report at 11-12. The very high quality imaging that D-HDTV will permit, transcending a high level of consumer satisfaction in the home video and entertainment industries, has numerous applications in virtually every industry sector. An interoperable digitally-processed HDTV broadcast transmission standard for consumer application can revolutionize America's communications infrastructure and can best preserve America's position in computer electronics and related innovative fields.[8] TCI predicts that a focused, concerted effort can lead to the development, in less than ten (10) years, of a prototype compressed broadcast D-HDTV transmission technology in 6 MHz,

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[7] See, e.g., Comments of Broadcasting Technology Association, Japan (filed November 17, 1987) at 5; Comments of ATSC (filed November 18, 1987) at Exhibit 3, p. 2, Exhibit 4, App. 2 (studio production standards); Comments of Matsushita Electric Corporation of America (filed November 18, 1987) at 7; Comments of Zenith Electronics Corporation (filed November 18, 1987) at 6 (The Zenith hybrid system, although employing conventional analogue transmission technology, uses digitally-processed information to achieve part of its enhancement).

[8] The program production and consumer video industries should be in a position to benefit from D-HDTV commonalities with the industrial sector as they develop. The Commission's Tentative Decision as to the HDTV proposals under consideration, however, would likely foreclose this necessary flexibility for terrestrial television.

although widespread use of the technology, particularly in an interoperable operational setting, will not take place for some time thereafter.

IV. RECOMMENDATIONS

TCI urges the Commission to evaluate the enhanced television proponent systems that are NTSC compatible and that require only 6 MHz bandwidth and to adopt a Further Notice as to which of these is the most suitable as the interim ATV transmission standard. TCI further recommends that the Commission keep the broadcast and land mobile UHF freezes in effect as part of a "strategic reserve" of spectrum to accommodate, if necessary, future spectrum needs for D-HDTV as compression technology emerges. This frequency can later be assigned once 6 MHz D-HDTV transmission technology has been perfected.

In order to achieve the transition to D-HDTV, the Commission should urge and work closely in concert with the Department of Commerce and the National Aeronautics and Space Administration to foster the establishment, as appropriate, of an interindustry research consortium[9] to develop a 6 MHz D-HDTV transmission standard. Extensive objective consumer testing is a necessary prerequisite to this effort. The effort should include members of the various facets of the telecommunications industry as well

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[9] The National Cooperative Research Act of 1984, codified at 15 U.S.C. §§ 4301-4305, permits competitors to form joint research and development ventures for development and testing of new technology.

as members of the computer electronics, data processing, integrated imaging, and other industry sectors that would benefit from the new technology.

TCI believes its recommended approach is consistent with the Commission's mandate to "generally encourage the larger and more effective use of radio in the public interest," 47 U.S.C. § 303(g). By not inaugurating HDTV with the proposed systems under consideration, the Commission will have reaffirmed the underlying rationale to its fortunate decision to reconsider Columbia Broadcasting Systems' color wheels and adopt RCA's all electronic color television:

> Before approving proposed standards, the Commission must be satisfied not only that the system proposed will work, but also that the system is as good as can be expected within any reasonable time in the foreseeable future. In addition, the system should be capable of permitting incorporation of better performance characteristics without requiring a change in fundamental standards. Otherwise, the danger exists that the standards will be set before fundamental developments have been made, with the result that the public would be saddled with an inferior service, if the new changes were not adopted, or if they were adopted, receivers already in the hands of the public would be rendered useless.

Color Television Report, 1 RR 91:31, 91:33 (1947).

Respectfully submitted,

TELE-COMMUNICATIONS, INC.

By: _____
B. Jay Baraff

_____
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November 30, 1988

ATTACHMENT 1

MOFFET, LARSON & JOHNSON, INC.

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ENGINEERING STATEMENT

IN SUPPORT OF COMMENTS

BY

TELE-COMMUNICATIONS, INC.

IN THE MATTER OF

ADVANCED TELEVISION SYSTEMS

AND THEIR IMPACT ON THE EXISTING TELEVISION BROADCAST SERVICE

MM DOCKET 87-268.

November 30, 1988

ENGINEERING REPORT

MOFFET, LARSON & JOHNSON, INC.

8203 LEESBURG PIKE CONSULTING TELECOMMUNICATIONS ENGINEERS FALLS CHURCH, VA. 22043

ENGINEERING REPORT
ON BEHALF OF
TELE-COMMUNICATIONS, INC.

I. INTRODUCTION

This Engineering Statement was prepared by Moffet, Larson & Johnson, Inc., consulting telecommunications engineers, in support of Comments by Tele-Communications, Inc. in the matter of Advanced Television Systems and Their Impact on the Existing Television Broadcast Service, MM Docket 87-268.

In less than two years, the present television standard, commonly known as NTSC[1], will be a half-century old. In 1941, the NTSC transmission standard established the basic parameters for broadcast television, including maximum resolution, aspect ratio, and frame rate. Working within that framework, numerous video services sprang forth to make television a major source of entertainment and information for the public. The demand for heightened realism in television pictures led to the development of color television and numerous improvements in the equipment used to televise, record, transmit and receive standard NTSC video.

Advances in technology by the 1970s led to the development by NHK (Japan Broadcasting Corporation) of a separate, new high-definition television (HDTV) system. This system is capable of displaying an image quality comparable to 35mm film, but it is not a transmission system due to its extreme bandwidth requirements. For example, NHK/HDTV in its raw form would require five contiguous NTSC channels or 30 megahertz to convey the picture.[2] The need for much more radio frequency spectrum, not to mention the incompatibility with present receivers and broadcast equipment, has delayed introduction of HDTV. Both Japan and the European community have developed spectrum-efficient HDTV systems intended for distribution by direct broadcast satellite. Neither group has yet established an HDTV system for terrestrial broadcast.

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1 The National Television System Committee (NTSC) was convened in 1940 to establish technical standards for a monochrome television broadcast system.

2 NHK has developed a bandwidth-compressed HDTV system, known as MUSE. This system is encodes the 1125-line/60-field format into a signal requiring 8.1 MHz, approximately one and one-third times the spectrum used by NTSC. Because the required bandwidth is not compatible with the U.S. broadcast TV allocation system, MUSE is considered of primary value in direct broadcast satellite service.

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ON BEHALF OF
TELE-COMMUNICATIONS, INC.

There are a number of promising techniques under development to provide Advanced Television Service (ATV). For purposes of discussion in this report, the proponent systems are divided into two groups, those systems which comply with the present 6 MHz allocation structure, and those which require more than 6 MHz of spectrum. All use an analog transmission format.[3]

Within the 6 MHz bandwidth group are two subgroups, determined by NTSC receiver compatibility. Several of these systems are compatible with existing NTSC receivers, but provide some combination of reduced NTSC artifacts, wider aspect ratio, and increased resolution for specially-equipped receivers. These systems are defined herein as enhanced-definition television (EDTV). There are other proposals that are not compatible with NTSC which propose to occupy no more than 6 MHz; constrained only by 6 MHz bandwidth, optimum image processing and modulation schemes may be utilized.

A second major group provides higher resolution and/or improved freedom from artifacts, but requires more than 6 MHz spectrum. Again, these systems fall into two subgroups; those which add an augmentation channel (usually 3 MHz or 6 MHz wide) in addition to the NTSC bearer channel, and those like MUSE that require a contiguous block of spectrum larger than 6 MHz.

This report discusses technical and regulatory issues involving allocation-compatible and non-compatible approaches: those factors which affect the quality of present NTSC services, require additional spectrum allocations, complicate interchange between various television media, and affect advancement of future.

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[3] The SCHDTV system proposed by Zenith Corp., Glenview, Illinois, is an analog/digital hybrid format.

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ENGINEERING REPORT
ON BEHALF OF
TELE-COMMUNICATIONS, INC.

1) The impact of ATV systems requiring additional spectrum in the UHF-TV band must be critically assessed in terms of possible interference effects to existing UHF broadcast service.

The present broadcast transmission standard, NTSC, serves the public well and will not disappear for many years. However, relaxation of UHF-TV interference standards and allocation taboos to accommodate High Definition Television (HDTV) most certainly will degrade present television service. Without question, more detailed spectrum analysis is required before a system choice can be made.

In the interim, it is highly unlikely that a de facto HDTV standard will emerge, so long as the NTSC broadcast transmission standard is maintained by the FCC. The challenge to provide substantial improvements in video quality has prompted considerable research into methods to improve NTSC or provide apparent HDTV quality within a reduced bandwidth. Today there are a number of promising techniques for the improvement of United States broadcast video which may be divided into two primary groups: those operating within the present 6 MHz NTSC channel, and those operating with a separate augmentation channel of 3 MHz or 6 MHz width in addition to the present NTSC channel.[4]

On the basis of preliminary engineering studies, the FCC Advisory Committee[5] reported that "sufficient spectrum capacity in the current TV allocations might be available" to allow all existing full-service TV stations with an augmentation channel. However, this view makes several fundamental assumptions. First, it assumes that some present UHF channel separation requirements, often referred to as "taboos", may be eliminated. Second, it assumes that the cochannel and adjacent channel interference protection requirements may be "substantially" relaxed from what they are now. Third, augmentation channels may eliminate most, if not all of the Low Power Television (LPTV) and translator service carried on UHF-TV channels, as well as spectrum reserved by the Commission for

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4 Some systems propose to wholly replace the NTSC signal with an improved, non-compatible 6 MHz signal channel. Since the signals are not receiver compatible, these proposals are unlikely to prevail in this proceeding and are not discussed herein.

5 On November 17, 1987, the FCC established an Advisory Committee on Advanced Television Service to study technical and policy issues related to ATS.

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the land mobile radio industry for future expansion.[6] Fourth, introduction of broadcast HDTV using separate augmentation channels requires spectrum not available to other television media, such as cable television, Instructional Television Fixed Service (ITFS) and Multipoint Distribution Systems (MDS).

The present television allocation standards provide for a variety of protective taboos involving the second, third, fourth, fifth, seventh, eighth, fourteenth and fifteenth adjacent channels of UHF-TV stations. Elimination of some UHF-TV allocation taboos may be possible if improvements in receiver performance are mandated. For example, local oscillator radiation in HDTV and new NTSC receivers may be reduced, thereby relieving interference from these receivers to HDTV and NTSC service. However, these improvements would not apply to the millions of older NTSC sets, possibly creating an undetermined amount of interference to HDTV and NTSC reception. Similarly, receiver intermodulation effects involving HDTV-HDTV and NTSC-HDTV signals depend on the specific characteristics of the HDTV signal. Until we know the modulation scheme, we cannot determine which taboos can be relaxed.

Prediction of UHF-TV cochannel and adjacent channel interference is similarly problematic. The spectral characteristics of 3 MHz and 6 MHz augmentation channels will be considerably different from other UHF NTSC signals, to be sure. Some characteristics proposed may reduce interference to cochannel and adjacent channel NTSC service, among these are pure single-sideband modulation and reduction or elimination of synchronizing pulses. However, differences in HDTV augmentation channel signals relative to NTSC signals may limit the effectiveness of frequency offset, a factor which has provided much closer spacing of currently allocated cochannel NTSC services. The estimation of cochannel and adjacent channel interference from HDTV augmentation signals cannot be known without psycophysical testing using actual prototype HDTV systems. Unfortunately, very few of the proposed systems are in operation, and many still require months or years to refine and build.

Development of HDTV for every full-service television station through the addition of separate augmentation channels must rely on availability of vast amounts of UHF-TV spectrum. Initial studies[7] suggest that not enough UHF broadcast spectrum may be available to

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6 [see engineering study contained in comments of Association of Maximum Service Telecasters - need cite]

7 Initial Comments of The Association of Maximum Service Telecasters in MM Docket 87-268, November 18, 1987.

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TELE-COMMUNICATIONS, INC.

provide 6 MHz augmentation channels, while 3 MHz augmentation channels may be in sufficient supply if LPTV and translator services are eliminated where necessary, along with UHF channels reserved for the land mobile industry.[8] Most severely impacted will be large markets, where most viewers reside.

An HDTV system employing a separate augmentation channel will require additional spectrum not necessarily available to all television media. Cable television service are likely to prefer a broadcast HDTV signal that can be frequency-translated directly into the cable system, in the manner that TV signals carrying NTSC Color and Multichannel Sound are carried now. If separate augmentation channels are required for HDTV, however, cable services would have to increase system bandwidth by 3 MHz or 6 MHz for each broadcast channel carried - a total possible increase of fifty percent or one-hundred percent, respectively, in system bandwidth.

Increasing system bandwidth is economically infeasible for many cable services since it may require new amplifiers, equalizers, tuner/decoders, and possibly even the cable itself. Cable Television Relay Service Stations (CARS), used by many cable systems for signal distribution, also have insufficient spectrum to support any HDTV approach that requires additional channel bandwidth. In an effort to conserve valuable spectrum, cable services would be forced to delete some television services to accommodate augmentation channels, develop a non-compatible (but spectrum efficient) HDTV system, or not carry HDTV at all.

Video services such as ITFS and MDS would have to find supplementary spectrum, presumably within their service, to carry HDTV augmentation channels. Even if spectrum were available, complicated frequency conversion or tuning arrangements would be required for cable and other non-broadcast television media if HDTV relies on separate augmentation channels.

Studio Transmitter Link (STL), Intercity Relay (ICR) and Electronic Newsgathering (ENG) systems are already in heavy demand with existing 6 MHz NTSC video/audio. These vital services would be severely impacted by ATV systems requiring additional spectrum for augmentation channels.

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8 The FCC reallocated a number of UHF-TV channels to the land mobile service in General Docket No. 85-172.

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Transmission costs are a factor yet to be explored by the FCC or its Advisory Committee. Construction of UHF augmentation channels involves staggering costs for additional transmitter(s), antenna, and transmission line or waveguide. Existing towers may not support the additional antenna systems. UHF transmitter power costs for an additional 3 mHz or 6 MHz channel may be prohibitive. Smaller market and some independent stations may lack the financial means to provide HDTV that relies on separate augmentation channels, thereby reducing programming opportunities for some television services.

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2) Recent studies tend to indicate the penetration of HDTV in consumer homes will be slow. The current haste in selecting an HDTV standard presents the distinct possibility of establishing a less-than-optimal system, and may hinder future advancements in HDTV and in home video technology.

A study completed this year for the NTIA[9] suggests a gradual penetration for HDTV:

> "If the growth path of ATV receivers and VCRs traces the historical sales tracks of conventional color television receivers, videocassette recorders, home computers and television receive-only [satellite] antennas, the new products will achieve one percent household penetration about ten years from now...[and] may reach 25% in about fifteen years and in twenty years may exceed 70% household penetration."

The report discusses the uncertainties of growth predictions, suggesting an array of scenarios which may further inhibit ATV, such as continuing uncertainty about spectrum constraints and receiver standards, delay in research and development programs, high ATV product prices, poor economic conditions, etc.:

> "Should these illustrative conditions arise, wholly or in part, it is quite conceivable that the one percent threshold would not be realized until well after the year 2000, and that subsequent growth would also be dampened."

On the other hand, several steps may be taken that support more rapid diffusion of ATV products, including timely and decisive regulatory action respecting standards and spectrum, and rapid development of high-quality, moderately-priced consumer equipment and program sources.

The analysis prepared for NTIA supports the position that an HDTV system requiring less development time, minimal spectrum regulation issues, and moderate pricing would be most viable. The introduction of ATV receivers based on enhancements compatible with NTSC video and operating without supplementary augmentation channels meets these

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9 Economic Potential of Advanced Television Products, Report by Darby Associates for the National Telecommunications and Information Administration, April 7, 1988.

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factors. ATV systems relying on NTSC plus augmentation channels, however, will require more development time, will have complicated allocation issues to resolve, and are highly likely to cost more than enhanced NTSC systems in both transmission and reception.[10] The augmentation channel approach will certainly deter further advancement of ATV systems, such as development of digital high-definition television (D-HDTV), perhaps killing it entirely.

The TV displays used by most viewers are CRTs (cathode ray tubes, better known as "picture tubes"). Realistically, the maximum size of these CRT displays are limited by the unit cost, cabinet size, and weight, to a diagonal dimension of about 30 inches. (CRTs up to 45 inches have been developed, but the cost, size, and weight of these units are prohibitive for most consumers.) A diagonal of 30 inches results in a picture height of about 18 inches (based on a 4:3 aspect ratio). It has been customary to evaluate NTSC at a viewing distance of three times the picture height and HDTV systems at four times the picture height,[11] which works out to a distance of 54 inches (4-1/2 feet) for NTSC and 72 inches (6 feet) for HDTV (assuming the same CRT picture height for both.

Most homes appear to have television viewing distances of nine to 12 feet, regardless of picture size. (This distance is probably due mostly to furniture arrangements and room size.) For the 30-inch screen example, these distances equal six to eight picture heights. Within this common range of distances, it is doubtful that a large percentage of the viewing public will be able to discern a difference between HDTV and NTSC, particularly if EDTV enhancements are applied to the NTSC picture.[12]

While prompt introduction of ATV technology is desirable, the push to develop a terrestrial HDTV system requiring a complicated augmentation channel approach that is possibly subject to interference and propagation limitations is not good engineering. As will be discussed later herein, other more suitable technologies are at hand to provide HDTV service for the future.

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10 The economic impact of complex ATV systems is discussed in the FCC's Tentative Decision and Further Notice of Inquiry in MM Docket 87-268, released 9/1/88, at 38-39.

11 A standard employed by the CCIR (International Radio Consultative Committee) and other broadcast authorities.

12 While projection systems provide very large picture sizes with the potential to reveal high picture quality, equipment cost and bulk is expected to keep sales low for a number of years. Projection systems also suffer from visual defects, such as washout from extraneous room light, off-axis brightness loss, and focus and registration problems which tend to limit picture quality.

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3) The ultimate goal of consumer HDTV should be image quality and aspect ratio similar to 35mm film with several channels of Compact Disc-quality audio. However, the HDTV proponent systems which rely on separate augmentation channels may not be able to deliver this quality to most viewers due to the vagaries of UHF signal propagation. Digital transmission has been shown to be more resistant to interference than analog format transmission.

Reliance on augmentation channels for HDTV broadcasting presents a number of problems. Foremost is the difference in propagation between the NTSC baseband on one frequency and a related augmentation channel on another frequency. UHF signals, because of their shorter wavelength, are subject to more attenuation by terrain shadowing, man-made obstructions, and absorption through trees, buildings, etc. Even with identical transmit and receive sites, it is likely that some viewers will receive an acceptable picture on the VHF channel (channels 2-13) carrying the baseband NTSC signal, but will not receive a usable augmentation channel signal on the UHF channel. The reverse condition is also possible.

Increased terrain attenuation of UHF relative to VHF increases the number and size of "holes" in the coverage area, meaning that the service area of an augmented HDTV service will be smaller than the NTSC baseband signal (if the NTSC signal is carried on a full-power VHF station). A portion of the viewing public will be foreclosed from receiving these HDTV transmissions.

UHF reception is often inadequate on indoor "loop" antennas, due to absorption of the signal as it travels through walls of the building, and because these antennas have relatively low gain. An outdoor UHF receiving antenna may be required to provide a sufficiently noise-free, multipath-free signal. This may not be possible for viewers in communities with covenants against outdoor antennas of any kind.

Transmission of EDTV within the station's present channel (whether the channel is VHF or UHF) makes it likely that a given viewer with satisfactory reception has the proper conditions to also receive the picture enhancements. This is less likely for augmented HDTV service.

Present television transmission is an analog process; picture information is conveyed by a continuously-variable carrier which follows the brightness (luminance) of the picture. Any disturbance of the incoming signal, such as multipath-delayed signals (ghosting in both terrestrial broadcast and cable systems), noise, or interference are impressed on the picture information. Digital transmission, on the other hand, converts the information into a binary signal of "ones" and "zeroes".

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Moderate disturbances characteristically have a lesser effect on digital signals, since the disturbance must reverse the state of the ones and zeroes to interfere. Further, digital transmissions can employ "error correction" within the data stream, thus detecting and correcting for erroneous bits. This technology is commonplace in the computer industry.

As an ultimate approach to HDTV, digital transmission offers clear advantages over analog transmission, including consistent performance, greater resistance to interference, and easier adaptation to sophisticated signal processing for both transmission and reception.

Recognizing the advantage of digital transmission, NASA (the National Aeronautics and Space Administration) has announced its intention to design a digital high-definition television system.[13] NASA plans to develop a D-HDTV by 1996 as a "baseline for the video system" of its space program. NASA's development of D-HDTV suggests numerous applications to industry and the public in the years to follow.

Digital television, for all its advantages, appears to be an inevitable development. If support and effort is directed toward 6 MHz broadcast digital TV, it could become a reality within ten years, which is not a long period of time, in consideration of the predictions of gradual penetration of HDTV systems in the home (even if HDTV were immediately adopted).

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13 "NASA Intends to Develop HDTV System", Multichannel News, pg. 39, October 24, 1988.

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4) Development of recording techniques, control systems, image processing and displays, (some of the primary components of television) show a definite trend toward digital systems. The analog HDTV approaches being advanced today may be superseded by digital video technology in a relatively short period of time.

The recent history of electronic engineering indicates that in most applications, subsystems similar to the types used in television have transferred from analog designs to digital designs. The most recent example of a shift in a major consumer system is the transition from analog audio on long-playing record and tape to digital audio via Compact Disc (CD) and Digital Audio Tape (DAT). The Compact Disc medium illustrates the economies of large-scale integration of digital circuits used in the player, while providing consistently high quality audio via the digital medium.

Other systems in consumer equipment have experienced transition from analog to digital format, as well. The tuner in most high-performance television and radio receivers are now digitally-controlled employing frequency synthesizers and digital displays. So are timers, remote controls, color subcarrier detectors, luminance channel comb filters, and other devices. The distinction between digital and analog circuitry often becomes quite blurred at the level of integrated circuits or "chips" within television equipment, where many functions are carried out by hybrid devices which rely on the precision and reliability available from digital processes.

As flat-screen displays develop, it is likely that these devices will employ digital systems to process, store, and scan the electronic image. There is evidence to suggest that future television processes, including encoding and transmission, would be more precisely, consistently, and economically handled in the digital domain.

For example, digital VCRs are already in use by TV production centers, television stations and networks, and much of the image processing, titleing and special effects are accomplished with digital circuitry. Digital television equipment will continue to replace elements of the broadcast chain, including parts of the TV receiver. Thus, establishment of a D-HDTV broadcast system is part of a natural progression from analog to digital systems.

Development of another analog standard for high-definition television may be short-sighted and short-lived, eventually to be replaced by a superior digital medium. The establishment of analog HDTV systems, especially those requiring complex and expensive augmentation channels, may leave broadcasters with no room to implement a truly superior approach.

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Establishment of an ATV system within the 6 MHz NTSC-compatible domain provides an excellent interim standard, and provides time to develop a more optimal digital (D-HDTV) system as the next-generation standard.